

**BEST AVAILABLE COPY**

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau

INTERNATIONAL BUREAU

(43) International Publication Date  
14 February 2002 (14.02.2002)

PCT

(10) International Publication Number  
**WO 02/13586 A1**

(51) International Patent Classification: H05K 3/00, C09J 2/00. (51) Designated States (optional): AE, AL, AQ, AT, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CN, CR, CO, CR, CU, CZ, DL, DK, DM, DZ, EC, ER, ES, FI, GB, CD, GE, GR, GM, HR, HU, ID, IL, IN, IS, JP, KR, KP, KR, LZ, LC, ME, LU, LS, LT, LV, MA, MD, MG, MK, MN, MW, ML, MZ, MO, NZ, PL, PT, RO, RU, SD, SE, SI, GE, SL, TD, TM, TR, TZ, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(21) International Application Number: PCT/US01/22414

(22) International Filing Date: 26 July 2001 (26.07.2001)

(23) Filing Language: English

(26) Publication Language: English

(30) Priority Data: 09/03 L476 3 August 2000 (03.JR.2000) US

(71) Applicant: HAMILTON SUNSTRAND CORPORATION (US/US); One Hamilton Road, Windsor Locks, CT 06096-1010 (US).

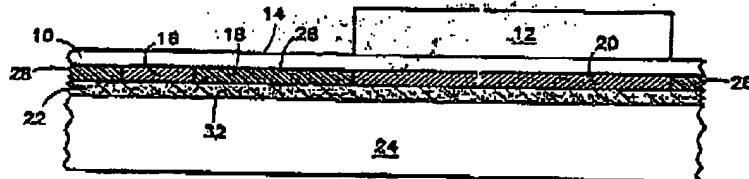
(72) Inventor: WARIN, Jairo, Kuniro; 5 Denebster Wood, Granby, CT 06035 (US).

(74) Agent: STEPHENSON, Gregory, E.; Hamilton Sunstrand Corporation, One Hamilton Road, MS 1-LPC18, Windsor Locks, CT 06096-1010 (US).

Published — with International search report  
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of comments;

For two-letter codes and other abbreviations, refer to the "Guide to the Patent Office and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) THIS ADHESIVE BONDING OR PRINTED CIRCUIT BOARDS TO HEAT SINKS



(57) Abstract: Voids (26) at the interface of a printed circuit board (10) bonded to a heat sink (24) which traps heat transfer from a heat generating electronic component (16) mounted on the printed circuit board (10) to the heat sink (24), and thus limit the density of voids at the interface of the printed circuit board (10) to the heat sink (24) is formed by a method wherein the adhesive adhesive layer (22) and a thermosetting adhesive layer (20). The latter fills the voids and thus provides for greater thermal conductivity from a heat generating component (16) to the heat sink (24) with the result in increase in heat rejection (20).

WO 02/13586 A1

WO 02/13585

PCT/US01/22414

Other objects and advantages will become apparent from the following specification taken in connection with the accompanying drawings.

**Brief Description of the Drawings**

Fig. 1 is a fragmentary, sectional view of a printed circuit board/heat sink assembly made according to the prior art;

Fig. 2 is a view similar to Fig. 1 but illustrating such an assembly made according to the present invention; and

Fig. 3 is a flow diagram illustrating a sequence of steps used in a preferred embodiment of the method of the present invention.

**Best Mode for Carrying Out the Invention**

Referring to Fig. 1, a prior art construction of a printed circuit board/heat sink assembly is illustrated. The same is seen to include a printed circuit board 10 of conventional construction which mounts at least one heat generating electronic component 12 on one side 14 thereof. The printed circuit board 10 includes copper traces 16 (only one of which is shown) which, as is well known, serve as electrical conductors between the various electronic components mounted on the printed circuit board 10. It will be particularly observed that the copper trace 16 illustrated in Fig. 1 extends somewhat from the side 18 of the printed circuit board 10 opposite the side 14. As mentioned previously, the extension will typically be in the range of 0.002-0.003 inches.

Also on the printed circuit board 10 is a thermal pad 20 of conventional construction and typically formed of a thin layer of copper or the like.

A layer of acrylic based pressure sensitive adhesive 22 is located adjacent the side 18 of the printed circuit board 10 and in contact with the copper traces 16 and the thermal pads 20 and bonds a conventional heat sink 24 thereto. In the usual case, voids 26 will exist between the copper traces 16 and/or the thermal pads 20 as mentioned previously. This is due

WO 02/13586

PCT/US01/23414

to the fact that the pressure sensitive adhesive 22 is not particularly flowable and cannot be caused, in conventional processing, to fill the voids 26.

Turning now to Fig. 2, a printed circuit board/heat sink assembly made according to the invention is illustrated. Where like components are employed, they are given the same reference numerals given to the prior art construction in Fig. 1 and will not be redescribed. The principal difference is the fact that the voids 26 have been substantially filled with bodies 28 of an adhesive. In the usual case, voids will occupy less than 5% of the space between the circuit board 10 and the heat sink 24. The adhesive bodies 28 are typically formed of a thermosetting epoxy adhesive which is flowable and then cured in place.

Turning now to Fig. 3, a highly preferred embodiment of the method by which the assembly illustrated in Fig. 2 is formed will be described. However, it is to be understood that while this embodiment described represents the best mode contemplated by the inventors, variations in the method are contemplated and no limitation to the highly preferred embodiment to be described is intended except insofar as set forth in the appended claims.

An initial step in the method is illustrated by a box 30 which is the provision of a two adhesive composite. In the preferred embodiment, the composite is formed of two layers of adhesive, one of pressure sensitive adhesive and the other of a thermosetting adhesive. However, more than one layer of each type of adhesive may be employed if desired. It is, however, important, that the composite have one face that is formed of the pressure sensitive adhesive 22 and the other of the thermosetting adhesive 28. Suitable pressure sensitive adhesives include acrylic based pressure sensitive adhesives available from Minnesota Mining and Manufacturing (3M Corporation) as 3M 9460 and 3M 9469. The thermosetting adhesive 28 may be an epoxy based adhesive which will adhere to the pressure sensitive adhesive 22 and is also available from 3M Corporation as AF 163. Alternate thermosetting adhesives 28 are also suitable.

WO 02/13686

PCT/US01/23414

In the usual case, a release liner (not shown) will be applied to the pressure sensitive adhesive layer. A similar release liner might also be applied to the layer of thermosetting adhesive but such is generally not necessary where the thermosetting adhesive, in its uncured state, is virtually solid and not particularly tacky. Such will typically be the case for thermosetting adhesives such as that identified above. As pressure sensitive adhesives identified are typically acrylic based, they provide a measure of vibration isolation (damping) just as in the prior art construction.

5 The release liners are then removed and the pressure sensitive adhesive layer 22 applied to a printed circuit board receiving surface 32 of the heat sink 24. The adhesive composite is then compressively rolled onto the surface 32 to achieve adherence thereto and to eliminate any gas pockets or bubbles that may form in the application process when the composite with the layer 22 is applied to the surface 32. This step is

10 illustrated at a box labeled 34.

15 At this point in the process, the printed circuit board is applied to the thermosetting adhesive layer as illustrated at a box 36. The resulting assembly is then placed in a conventional vacuum bag and subject to vacuum. This operation performs two functions. A first is to draw air or gas out of the pockets 28 as would otherwise exist. A second purpose is to cause the vacuum bag to collapse upon the assembly and compress it so as to drive the copper tracer 16 and the thermal pads 20 against the layer of thermosetting adhesive to form the bodies illustrated in Fig. 2 as shown by the box 38.

20

25

At this point in the process, the printed circuit board is applied to the thermosetting adhesive layer as illustrated at a box 36. The resulting assembly is then placed in a conventional vacuum bag and subject to vacuum. This operation performs two functions. A first is to draw air or gas out of the pockets 28 as would otherwise exist. A second purpose is to cause the vacuum bag to collapse upon the assembly and compress it so as to drive the copper tracer 16 and the thermal pads 20 against the layer of thermosetting adhesive to form the bodies illustrated in Fig. 2 as shown by the box 38.

The assembly is then heated as shown by a box 40. Initially the heating of the thermosetting adhesive lowers its viscosity, causing the same to liquify and flow into the pockets 28 that were previously evacuated by the step performed at the box 38. At the same time curing of the resin is initiated. When curing is complete the thermosetting adhesive will have formed the rigid bodies 28. Preferably the thermosetting resin will liquify and cure at temperatures on the order of 200°F. This temperature is sufficient to achieve a cure while at the same time, insufficient to cause thermal

WO 02/13586

PCT/US01/22414

## Claims

1. A method of bonding a printed circuit board to a heat sink comprising the steps of:
  - a) providing an adhesive composite having at least one exposed layer of pressure sensitive adhesive and at least one exposed layer of thermosetting adhesive;
  - b) sandwiching the composite between a printed circuit board and a board receiving surface on a heat sink with the exposed layer of pressure sensitive adhesive facing said board receiving surface and the exposed layer of thermosetting adhesive facing the printed circuit board;
  - c) subjecting the assembly resulting from step b) to both a vacuum and heat to remove gas between the heat sink and the printed circuit board and to cure the thermosetting adhesive.
2. The method of claim 1 where step a) is succeeded by and step b) is preceded by the step of compacting the adhesive composite to remove gas bubbles.
3. The method of claim 2 wherein the step of compacting includes compacting the adhesive composite against the heat sink.
4. The method of claim 3 wherein step c) also includes compressing the assembly resulting from step b).
5. The method of claim 1 wherein step c) also includes compressing the assembly resulting from step b).
6. A printed circuit board and heat sink assembly made according to the method of claim 1.

WO 02/13586

PCT/US01/23414

7. A method of bonding a printed circuit board having at least one heat generating component mounted thereon to a heat sink comprising the steps of
  - a) sandwiching at least one layer of pressure sensitive adhesive and at least one layer of thermosetting adhesive between the heat sink and the printed circuit board with a pressure sensitive adhesive layer contacting the heat sink and a layer of thermosetting adhesive contacting the printed circuit board;
  - b) compacting the assembly resulting from step a) under vacuum to remove gas at or between the layers of adhesive; and
  - c) applying heat to the assembly resulting from step a) during or after the performance of step b) to cure the thermosetting adhesive.
8. The method of claim 7 wherein step a) is performed by locating an adhesive composite containing said layers between said printed circuit board and said heat sink.
9. The method of claim 1 wherein step c) is effective to additionally liquify the thermosetting adhesive to cause it to flow into void spaces on the printed circuit board caused by the vacuum.
10. A printed circuit board and heat sink assembly made according to the method of claim 7.
11. A printed circuit board and heat sink assembly comprising:
  - a) a printed circuit board;
  - b) a heat sink having a printed circuit board receiving surface spaced from said printed circuit board;
  - c) at least one layer of pressure sensitive adhesive and bonded to said heat sink;

Patent #CN2534775Y/Abstract

Heat-dissipating Structure for Electronic Elements on Print Circuit Board

The invention provides a heat-dissipating structure for electronic elements on printed circuit board, including a metal heat-dissipating plate and a layer of plate-like heatsink paste between the heat-dissipating plate and the electronic elements. The plate-like heatsink paste has a fixed shape, and is soft in normal condition, such as a silicon film comprising powdered heat-conductive material. The electronic elements disposed on one or both sides of the metal heat-dissipating plate, connect with the metal heat-dissipating plate by the plate-like heatsink paste, and then heat produced by the electronic elements is conducted to the metal heat-dissipating plate through the plate like heatsink paste, providing a conductive module for multiple electronic components.

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**